

Transmission, Distribution Lines Fault Prediction Using Z-Score Analysis

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ABSTRACT: Nowadays, there is a huge increase in demand for electrical energy. The main reason for that is increase in population. The depletion of non renewable resources also constitutes to increase in demand for electrical energy. One of most obvious example of this is increase in popularity of electric vehicles due to depletion of petrol resources. Hence it is becoming very important to conserve electrical energy and reduce its wastage. In order to do so it is necessary to analyze problem that cause wastage of electrical energy. One of the most important causes of wastage of electrical energy is occurrence of electrical fault. The term electrical fault means abnormal increase in electrical current which not only wastes the power generated but also cause damage to transmission, distribution lines and equipment. So it is very important to minimize occurrence of electrical fault. This paper presents a fault prediction method which uses ionization sensor and concept of z-score analysis to predict the occurrence of fault.

KEYWORDS: Fault prediction, Ionisation sensor, Fault detection, Theft detection, Z-score analysis, prediction with machine learning, Transmission line, IoT, PLC, fault prediction using machine learning., Anomaly detection

I. INTRODUCTION

The depletion of non-renewable resources is one of biggest concern on human mind. Thus it is important to conserve the electrical energy and reduce its wastage. One of the biggest causes in wastage of energy is occurrence of electric fault. The word fault means break or defect in machinery. The term electrical fault means abnormal increase in electrical current. Study states that on an average 40% of electricity generated in India is lost in transmission and distribution. Hence it is important to minimize occurrence of electric fault. Also due to occurrence of fault causes damage to the electric substation equipments like transformer, circuit breaker, current transformer and protection transformer etc. Moreover fault damages insulation between phase conductor and earth. Due to sudden increase in load current it also damages the equipments in industries and domestic appliances. The abnormal increase in current also causes excessive heating which can cause fire and explosion. If this electrical faults are not cleared immediately it could also cause potential danger to neighborhood. One of the problem is that clearing the fault is a time consuming process. As the fault is first detected in transmission substation, then they contact with the distribution substation for verifying the cause of fault and to clear it.

The wise man once said "Prevention is better than cure". The main objective of this paper is to overcome this problems and take immediate preventive measures as per required to avoid the upcoming fault. This paper presents an idea to develop a fault prediction system, so that occurrence of electrical faults can be avoided. In order to do so, concept of z-score analysis, with the help of PLC or IoT devices and cloud computing is used. With the help of this concept one can get aware of the future possibilities of fault and can prevent it.

II. WORKING

This fault prediction and theft detection system works on concept of ionization. When two wires are brought closer to each other, at certain point, the gap becomes so low that air between wires get ionized and breaks down. Thus spark strikes between two surfaces. This system uses this concept very well. The setup of this system includes connecting ionization sensors along the transmission lines specified between two towers. This can be done by placing parallel plates of ionization sensors on a strip equally spaced from each other. This sensor will detect ions present in the air and transmit that data to cloud through plc unit or a IoT device. Now the concept of z-score analysis would be used on that data to find out whether it crosses predetermined threshold. When the data collected from the sensor will cross threshold warning would be pinged at the respective area's distribution substation.

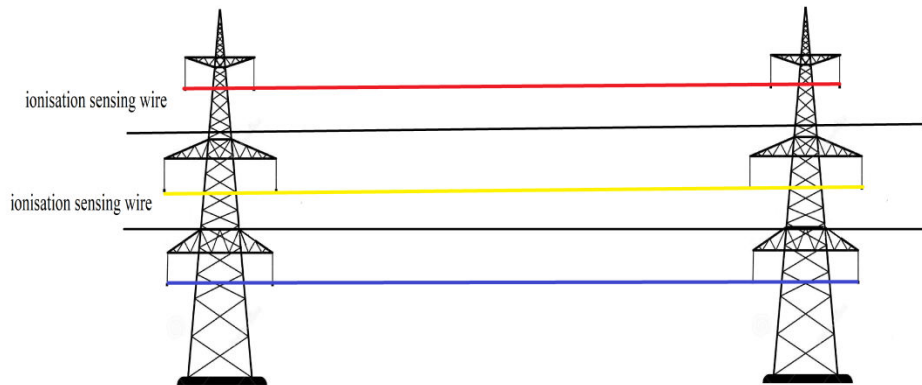


Fig. 1. Overview for the setup of the system

Note that warning would be pinged only if the ionization value crosses the threshold beyond certain tolerance for specific duration of time. For example when the wires are shorted the value of the ionization would be at 100% and it would led to a spark so during the time when ionization tends to gradually increase the sensor would ping the warning at 70% so that the respective officials of that area could take care of the upcoming fault and safe the equipments from damage. The wires can come close due to wind or by some other means for fraction of seconds so it is important that system only pings the fault if ionization value crosses threshold for certain period of time. The expected output of the system will be as per shown in Figure 2, from which when the dataset crosses the boundary limits for specific period of time the warning will be generated. GSM module and distance relay can enhance the system, so that exact location of fault can be determined. Also this would help system for theft detection of electricity, as if someone is stealing electricity by hooking method the ionization of that area would cross the threshold value and the respective official would get the warning and exact location with help of GSM module and distance relay.

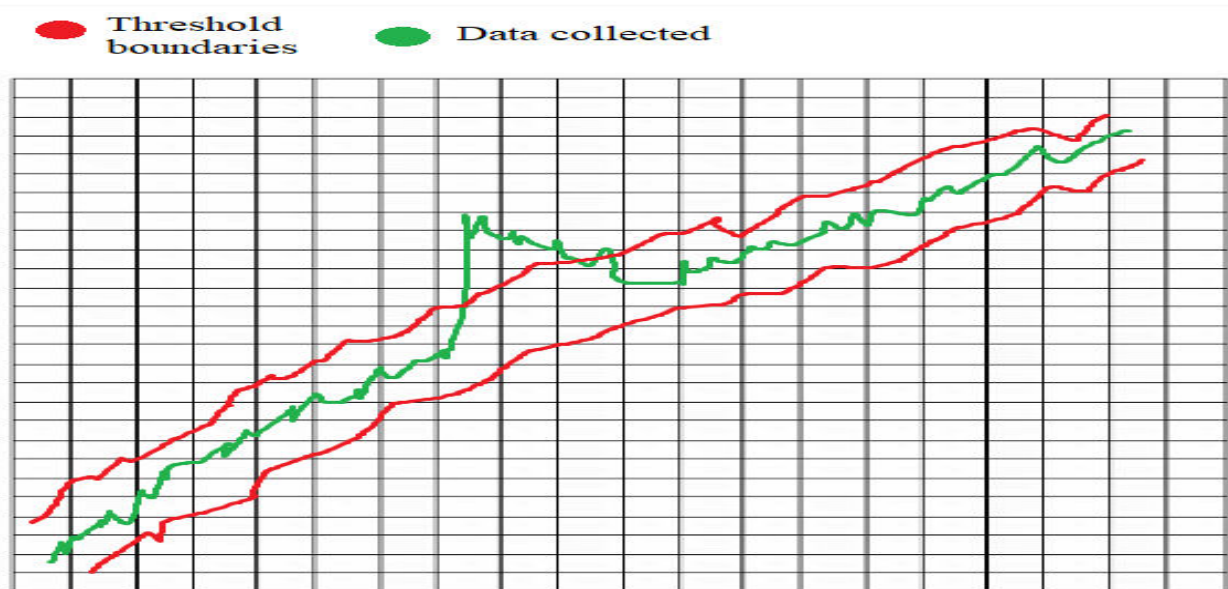


Fig. 2. Expected output graph of the system

III. METHODOLOGY

This paper involves both hardware and software design. The concept of this system includes two section:

- A. Z-Score analysis
- B. Roles of Ionization sensor, IoT device or PLC with cloud computing

The block diagram of the system is given in Figure 3, Concept of the system. The ionization sensor send data to cloud for z-score analysis through Iot or PLC devices then if there is any anomaly detection then it pings a warning with help of respective medium.

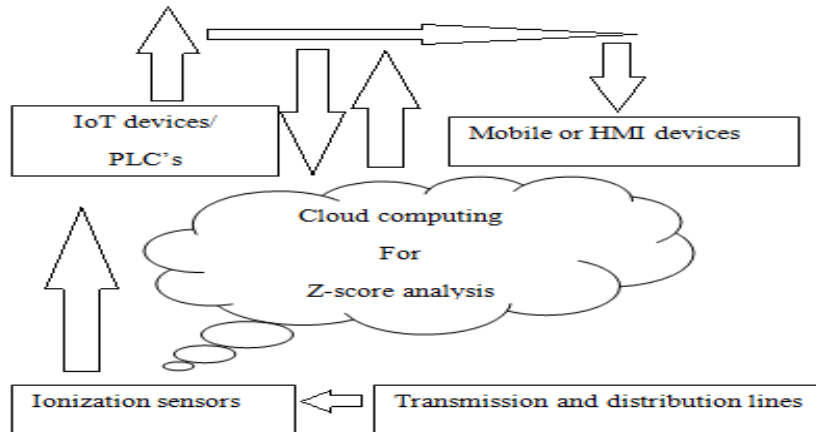


Fig. 3. Block diagram for concept of the system

A. Z-Score Analysis

In machine learning there is a concept known as anomaly detection. An anomaly is defined as something that deviates from standard or normal behavior. Basic idea behind anomaly detection is that a model is trained to collect and store large amount of data and when some irregularity or an oddity is observe inside the dataset model pings warning. There are several ways to carry out anomaly detection. One of the most renowned method is Z-score analysis. In order to understand Z-score analysis it is important to know three terms-

1. Mean

Mean- Mean is the average of the last r values.

$$M_n = \frac{\sum_{i=1}^r V_i}{r}$$

2. Z-score

Z-score is the product of C and square root of the mean of variation of last r values.

$$Z_n = C * \sqrt{\frac{\sum_{i=1}^r (V_i - M_n)^2}{r}}$$

3. Threshold

Thresholds are obtained by adding and subtracting Z-score from current value

$$T_n = V_i \pm Z_n$$

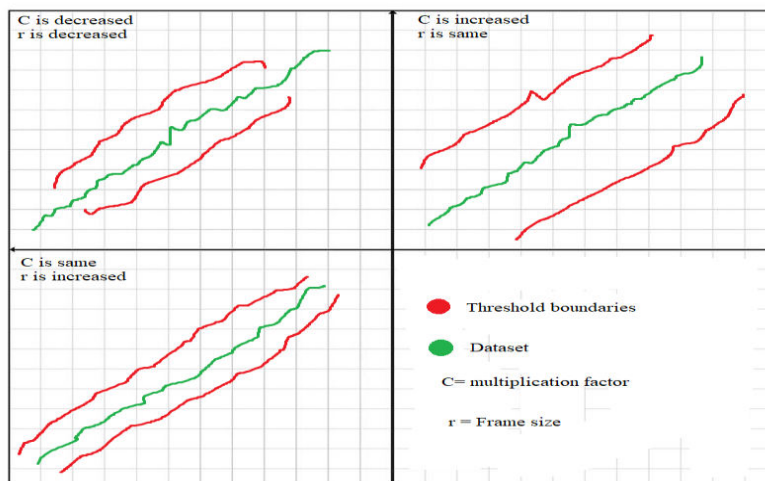


Fig. 4. Block diagram for concept of the system

Here r is frame size i.e. number of previous data points that will use to predict next data and C is multiplication factor. If we increase the value of C threshold boundaries move away from dataset and if we decrease the value of C the threshold boundaries move closer towards dataset. This happens because C is directly proportional to Z -score. If we increase the value of r shape of threshold boundaries starts changing such that starting point of threshold boundaries moves further along with dataset. So in Z -score analysis values of C and r are adjusted such that entire dataset is within the boundaries and all the anomaly points are outside the boundaries.

B. Roles Of Ionization Sensors, IoT or PLC Devices With Cloud Computing

The main function of IoT device or Plc in this system is to collect data from ionization sensor and transmit it to cloud. The ionization sensors are available in various types like parallel plate, cylindrical plate type, tubular etc. So for now with help of this sensor you can collect data for the analysis of faults and send it to IoT device or Plc. Now, on this cloud Z -score analysis would be performed on this data and if anomaly is detected IoT device will ping the warning with message whereas Plc will show the update on HMI screen. The Gsm module and distance relay can be connected to the IoT device in order to determine location of fault to make the system more efficient.

IV. PREDICTION OF DIFFERENT ELECTRICAL FAULTS

Following faults are observed regularly and can be cleared if it is predicted earlier.

1. Line to line fault

Whenever two phases are short circuited line to line fault takes place. It is also known as Phase to phase faults. This occurs if a piece of wire falls on the 2nd line it would be hanging and there is possibility of that wire would get touched with other phase and cause fault. So with this prediction system installed the air at the place where the wire is hanging, will get more ionized and there would be an anomaly detection with the help of data received from ionization sensor in Z -score analysis and IoT devices, will ping the update to the respective distribution substation to clear the wire to avoid fault.

2. Line to ground

When there is an insulation breakdown between single phase and earth line to ground fault take place. It is also called single phase to ground fault. Suppose there is accumulation of some sort of load for example ice on transmission line it would result in increase in sag of line or falling of a branch of tree there would be chances of breaking if the load is not cleared which would result in line to ground fault. In this case, as the two line conductors are apart from each other the ionization between them drops down, which is analyzed by Z -score in cloud computing from the data collected by ionization sensor and a warning would be pinged.

3. Theft detection

In certain area people try to steal the electricity by hooking the line conductor with wires due to which the ionization of that area experiences a sudden change by which the respective area distribution substation will find out that the theft is taking place. And with help of GSM module and distance relay the system can be more enhanced to get the location of the theft area. During theft detection there is also a chance of line to line, line to ground or line to line to ground fault which is dangerous and such cases can be avoided with help of this system..

V. CONCLUSION

This paper presents an idea for fault prediction and theft detection system by help of which not only wastage of electric energy would be reduced but also damaged caused to the substation, industrial equipments and domestic appliances would be avoided. This would result in decrease in maintenance cost for substation. The power cut because of the fault can be minimized. This could also save the life of birds if proper preventive measures are taken as per the studies nearly 1lakh birds are dead in 4200sqkm due to electrocution with transmission lines. Due to this system time consume for clearance of cause of fault can also be reduced. Also electricity theft would be quickly detected and proper actions can be taken against it as per the law.

VI. FUTURE SCOPE

One of road block in implementation of this system is availability of better ionization sensors. Ionization sensor that are available today are bit bulky so in future it is expected that when better ionization sensor within economical value and in shape of wire are available, it will make the system more efficient. So this would minimize chances of occurrence of fault.

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